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SSL

SUPSI SpaceLab
–
TIsat-1 Ground Segment Team

Operative Manual

SUPSI SpaceLab

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Revisions

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1.1	11.06.2010	IBo/PCe	Production (launch time) version.

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Contents

Acronyms and Terms

AGC	Automatic Gain Control
CCR	Capture and Compare Registers [?]
DoL	Days of Life (in-orbit mission duration)
ECC	Error Correcting Code
EOC	End Of Charge (related to batteries)
EOD	End Of Discharge (related to batteries)
EPS	Electric Power Supply
OBC	On-Board Computer
OPR	Orbit PRofile (related to datasets in telemetry)
GS	Ground Station
PV	Photovoltaic
RFPC	RF Power Checker
RX	Receive or Receiver
TX	Transmit or Transmitter
TU	Timing Unit
CBD	CPU Boot Delay: the time between boot of the CPUs as assigned by the TU.
WPM	Words per Minute, the Morse transmission rate measure.

Chapter 1

Introduction

TIsat-1 is the first staff and student made satellite of *SUPSI-SpaceLab*.

For communication *TIsat-1* relies on amateur radio frequencies which were coordinated with the International Amateur Radio Union (IARU).

This document describes

1. the radio communication system,
2. the modulation methods,
3. the communication frame architecture and
4. the frame details of *TIsat-1*.

This information will enable decoding of *TIsat-1*'s signals even without the specific software that *SUPSI-SpaceLab* has prepared for the mission.

Further a short installation and user guide for the demodulation and decoding software provided by *SUPSI-SpaceLab* is given.

Chapter 2

Space Segment

2.1 An Overview of *TIsat-1*

Figure 2.1 shows the structure of *TIsat-1* along with the naming convention for the sides. Four antennas are depicted: *TIsat-1* actually carries only two of the four antennas[1].

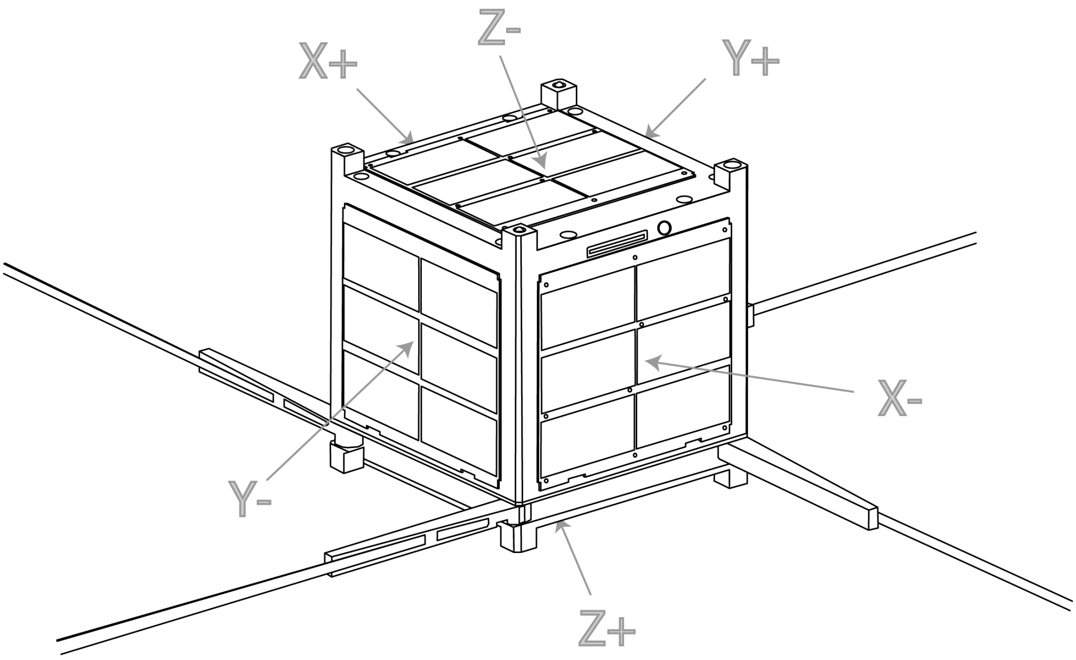


Figure 2.1: *TIsat-1*: structure.

[1]Emission efficiency was experimentally found to be better with only two antennas.

2.2 COMM Subsystems Overview

TIsat-1 carries two radio devices working in the UHF respectively in the VHF band. A home grown beacon transmitter is dedicated to downlink short telemetry (i.e. essential information) and operates in UHF (437.305 MHz) with CW modulation. The beacon is also used as emergency radio and first communication device, just after the launch. The second device is a commercial FM transceiver (Alinco) used for up- as well as for down-link. It is adapted to handle several audio tone modulation schemes providing an higher bit-rate than the beacon. This radio is used to transmit the full telemetry in the VHF band (145.980 MHz). The two radios relay each other during *TIsat-1*'s mission with a time-slice logic.

2.2.1 Mission Sequence

The four stage PSLV rocket is expected to cut-off thrust of PS4 (fourth stage) at liftoff $+1034.2s$. This time is called T6.
TIsat-1 will separate from the Launch Vehicle (LV) at $T6 + 135.4s$. Up to separation time the spacecraft is powered off.

2.2.2 Post Separation Operation

After separation, i.e. the spacecraft leaves the XPOD, complying with the CDS[2] rev. 11, *TIsat-1* will

1. wait for at least 900s before deploying antennas. While waiting, *TIsat-1* will sample the internal temperature and will activate the deployment system only if the temperature is above 0^oC, but not later than 130 min after separation. No communication will take place during this time.
2. After antenna deployment, for the next 900s, short beacon transmission are allowed. The Morse string "tisat1 hb9de" is transmitted.
3. After 1800s (30 min) nominal spacecraft operation is entered.

2.2.3 Nominal RF Operating Scheme

The two downlink devices (Beacon and FM transceiver) alternate each orbit. During even orbits the beacon is used, while the FM transceiver is used during the next (odd) orbit.
During the FM transceiver orbit, a data packet transmission is repeated for 25 seconds each minute, queuing 4 PSK packets with 1 FSK packet. Find additional information on packet encoding and transmission in the next sections.
The beacon transmission rate is toggled from slow (16 WPM) to fast-rate (100 WPM) every 32 orbits.

[2] CubeSat Design Specification.

2.2.4 Operating sequences

COMM operating sequences are tied to the *Operating Modes* and *Operating Cycles* of the spacecraft.

The spacecraft Operating Modes

TIsat-1 is programmed to periodically execute three basic operations during its nominal life:

1. perform **housekeeping** measurements and procedures and payload tests;
2. **transmit** data to the Ground Stations;
3. **receive** commands.

The firmware of the OBC is able to self configure the satellite depending on which operation has to be executed. A fixed timeslot is allotted to each operation; when the slot times out the current operation is terminated and the next is started.
The software and hardware configuration related to each operation is called *Operating Mode*.

There are five *Operating Modes*:

n.	Operating Mode	Timeslot (s)	Notes
1	Housekeeping	15	
2	Transmission with FM radio	25	TX_FM mode
3	Transmission with beacon	25	TX_Beacon mode
4	Reception	20	RX mode
5	Sleep	25	

Houskeeping mode: the CPU basically reads the sensors and stores the results in memory. This operating mode takes 15 seconds. No radio transmission is activated during this time.
When the housekeeping time expires, *TIsat-1* enters one of two transmission modes, unless energy saving is necessary, in which case the satellite enters Sleep mode.

TX_FM mode: this mode is entered during even numbered orbits and lasts 25 seconds. The satellite uses the FM radio going through its modulations schemes and packets: four operating cycles with PSK and one with AM-FSK packets. The same packet is repeated so many times as needed to fill the 25 seconds of the TX mode. After that the RX mode is activated.

TX_Beacon mode: this mode is entered during odd numbered orbits and lasts 25 seconds. The satellite uses the beacon (CW) to send the specific packets at two different data rates.

Slow rate: the transmission scheme is periodic in five steps

1. transmission of the callsign;
2. Beacon short packet type 1;

3. Beacon short packet type 2;
4. Beacon short packet type 3;
5. Beacon short packet[3] type 4.

The packets are repeated to fill the 25 seconds of the mode timeslot.

Fast rate: the Beacon ”Complete packet” described in section 2.3.5 is repeated over and over during the 25 seconds of the mode timeslot.

After that the Rx mode is activated.

Sleep mode: in this mode no activity occurs for 25 seconds. This is the power saving mode. It is activated either in eclipse, in case of emergency and over equatorial latitudes, where the satellite has the maximum exposition of the solar panels.

RX mode: the FM transceiver is turned on in receive mode and the satellite waits for commands from the Ground Stations. If no command is received within 20 seconds, the mode is terminated, otherwise the satellite keeps in RX mode until a "End of RX" command is received or the processor timeslot (max 5 minutes) expires.
The RX mode is the only mandatory mode for each cycle; its duration is at least 20s every 40s.

The spacecraft Operating Cycles

A sequence of three operating modes, that matches the basic operations of the satellite, is called a *Operating Cycle*.
Each *Operating Cycle* takes one minute to execute.

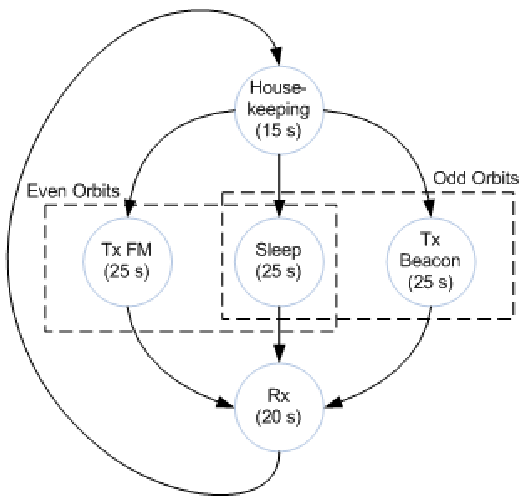


Figure 2.2: Operating modes (bubbles) and cycles (closed paths) of *TIsat-1*.

Note (fig. 2.2) that any closed path following the oriented edges of the graph represents one possible *Operating Cycle* and takes 1 minute to execute.

[3] Beacon Packets are described in section 2.3.5.

The scheduling and execution sequence of the operating modes depends on specific real time constraints. Decisions are based on energy availability, sunlight conditions[4], temperature, estimated position along the orbit, etc.
Depending on the situation, there can be cycles without TX state.

The Processor Timeslot

For redundancy purposes, the OBC of *TIsat-1* is built with two independent microcontrollers relaying each other periodically in control of the spacecraft.
The time allotted to each processor is called *Processor Timeslot* and, for *TIsat-1*, it is set to 5 minutes.
During the timeslot the processor executes 5 *Operating Cycles*.
The two microcontrollers are programmed to be functionally identical, so they behave the same way during each one's timeslot.

2.2.5 Beacon

The beacon transmitter is tuned to the RF frequency of 437.305MHz.
The output of the transmitter is switched on and off to achieve information transport. This procedure is commonly referred to as CW (Continuous Wave) or OOK (On-Off-Keying) modulation.

2.2.6 Transceiver

The transceiver used on *TIsat-1* is a FM device. Its carrier frequency is set to 145.980MHz according to the IARU coordinated frequency for the spacecraft and is modulated by audio tones injected via the microphone jack.

The term *modulation* used in the following always refers to *audio types of modulation*.

All types of modulation for the transceiver have been implemented in software and are part of the experimental payload for *TIsat-1*. The audio tones are generated by the OBC.

[4] During eclipse the batteries cannot be recharged, therefore the power consumption shall be limited.

2.3 Downlink

2.3.1 Beacon CW Type of Modulation

The transmission method is based on Morse encoding.
The data rates are the same as for the FM transceiver, i.e. 16 WPM at slow rate and 100 WPM at fast rate.

2.3.2 Alinco Audio-Morse Type of Modulation

A 880Hz tone of changing duration, interleaved with silence is synthesized by the OBC of *TIsat-1* (fig. 2.3) and is injected to the microphone input of the transceiver.

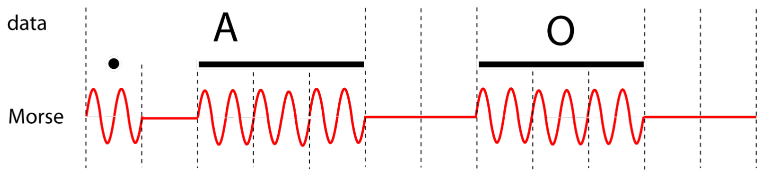


Figure 2.3: The Morse modulation.

The symbols dot (dit) and dash (dah) are coded with a short / long sound preceded and followed by silence. Silences have different durations depending on their position: inter-symbol, inter-character of the same word, inter-word.
The duration for symbols and silences in the scheme adopted for *TIsat-1* is reported in table 2.1 (1:2:5 scheme).

Object	Duration
Dot (dit)	base unit
Dash (dah)	3 dots
Inter-symbol silence	1 dot
Inter-character silence	2 dots
Inter-words silence	5 dots

Table 2.1: Morse symbol duration

The Morse data rate is expressed in *Words Per Minute* (WPM), where the reference word is ”PARIS”.
Table 2.2 shows the enconding for the standard word.

P		**A**		**R**		**I**		**S**	
· — — ·		· —		· — ·		··		· · ·	
	2		2		2		2		5

Table 2.2: Morse encoding of standard word "PARIS".

The duration of a dot in seconds can be computed as follows.
The word "PARIS" contains 10 dots, 4 dashes, 9 inter-symbol silences, 4 inter-character silences and 1 inter-word silence, which is equivalent to

$$(10 \cdot 1) + (4 \cdot 3) + (9 \cdot 1) + (4 \cdot 2) + (1 \cdot 5) = 44 \ dots. \tag{2.1}$$

Defining this value as *dots-per-word* (*dpw*), one can compute the time per dot as in equation 2.2.

$$TimePerDot = \frac{60s}{WPM \cdot dpw} \tag{2.2}$$

The Audio-Morse type of modulation for *TIsat-1* runs at 16 WPM at slow rate and 100 WPM at fast rate. Dot time for these rates is summarized in table 2.3.

Data Rate (WPM)	Dot time(ms)
16	85.2
100	13.6

Table 2.3: Dot time

Morse modulation with the FM transceiver has modest throughput compared to the other modulation schemes.

2.3.3 Alinco Audio-FSK Type of Modulation

The two logic symbols `'0'` and `'1'` are mapped to the audio tones, 1200Hz and 600Hz. The amplitude of the two tones is different and is tuned to favour the decoding process.

The digital raw data is Differential-Manchester encoded prior to modulation.
The chosen encoding scheme (fig. 2.4)[5] calls for a change at the beginning of each bit cell (regardeless of the data value) and further:

Data Value	**Center of Bit-Cell**
'1'	No change
'0'	Change occurs

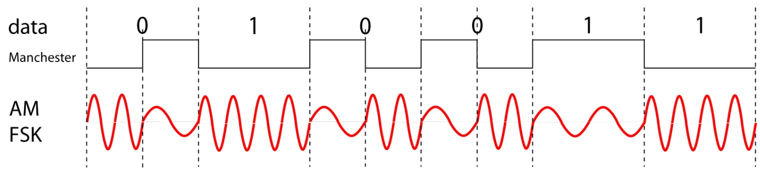


Figure 2.4: The FSK modulation with Manchester data enconding

With this modulation *TIsat-1* acheives a bit rate $BR \approx 100$ bit/s.
The minimum and maximum number of uninterrupted full tone periods can be calculated as follows:

$$N_{min} = \frac{1}{BR} \cdot \frac{1}{2} \cdot f_{tone} \tag{2.3}$$

$$N_{MAX} = \frac{1}{BR} \cdot f_{tone} = 2 \cdot N_{min} \tag{2.4}$$

[5] Documented as Biphase Mark Code in `WikiPedia`.

N_{min} numerical values:

$$N_{min\_600Hz} = \frac{1}{100} \cdot \frac{1}{2} \cdot 600 = 3$$
$$N_{min\_1200Hz} = \frac{1}{100} \cdot \frac{1}{2} \cdot 1200 = 6$$

2.3.4 Alinco Audio-PSK Type of Modulation

A tone of 1400Hz is the basis for the PSK modulation. One period of the tone ($T = \frac{1}{1400Hz} \approx 714\ \mu$s) represents one bit of data.

At the occurrence of each data bit of value `'1'`, the phase of the tone is reversed (shifted by 180°), otherwise no phase shift is introduced (fig. 2.5). This is actually Differential Phase Shift Keying modulation (DPSK).

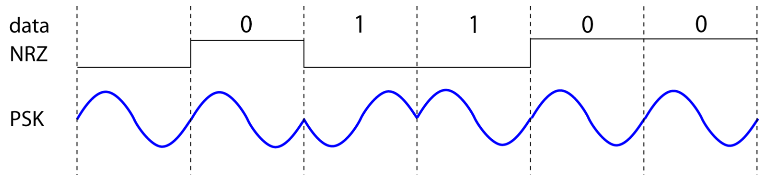


Figure 2.5: The PSK Modulation (DPSK)

With this modulation *TIsat-1* acheives a bit rate $BR \approx 1400$ bit/s.
PSK is used to download the complete telemetry of *TIsat-1*.

2.3.5 Beacon Packet Architecture

The Beacon of *TIsat-1* sends a set of instantaneous parameter values using Morse code. In order to make data packets as short as possible the encoding scheme of table 2.4 for every *nibble* of data[6] was chosen.
The 16 shortest Morse characters were mapped to the 16 hexadecimal values (0x0 . . . 0xF) possible with 4 bits, i.e. a nibble.
For *TIsat-1* this is referred to as *Morse short-form*.

Packets

The beacon sends six different packets of data.

n.	Packet Name	Data Rate (WPM)	Comment
1	Callsign	16	Contains *HB9DE* in plain Morse (no *Short-form encoding*).
2	Battery status	16	
3	Subsystems status	16	
4	Photovoltaic temperature	16	
5	Payload	16	
6	Complete	100	Collects all the above information

[6]The term *nibble* is largely used to define different quantities of bits. For this document a *nibble* is 4 bits. Two concatenated *nibbles* generate a *byte* (8 bits).

Nibble Value	Character	Morse Code	Length (dots)
0x0	E	·	1
0x1	I	··	3
0x2	T	–	3
0x3	N	–·	5
0x4	S	· · ·	5
0x5	A	·–	5
0x6	H	· · ··	7
0x7	D	– · ·	7
0x8	R	· – ·	7
0x9	M	– –	7
0xA	K	– · –	9
0xB	U	· · –	7
0xC	B	– · ··	9
0xD	5	· · · · ·	9
0xE	F	· · –·	9
0xF	L	· – ··	9

Table 2.4: Morse short format encoding for *TIsat-1*

The beacon is thought to be easily heard and understood by anyone with knowledge of the Morse code. Any standard Morse decoding software can be used to automatically put the *dit-dah* into text. Decoding can be acheived even by hand, following the rules listed in the next sections.
SUPSI-SpaceLab provides software to automatically gather, check, save and decode data from *TIsat-1*.

Battery status packet

The battery status packet shows the actual temperature and voltage of the two batteries of *TIsat-1*: a Lithium-Polimer (LiPo, 1400 mAh, 4V, nominal 3.6V) and a Lithium-Ion (LiIon, 2400 mAh, 4V, nominal 3.6 V).

The structure of the packet is shown in figure 2.6. Each square (numbered 1 ... 12) is one of *Short-form* Morse charactes encoding a 4 bit value (see table 2.4). The first box (*Sync*) on the left is the synchronization symbol (a non standard Morse symbol). Refer to table 2.5 for decoding.

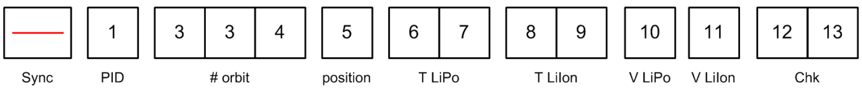


Figure 2.6: Beacon battery status packet

Character	Name
1	Packet ID and processor ID
2-4	Orbit number
5	Approximate latitude
6-7	Lithium-Polymer Temperature
8-9	Lithium-Ion Temperature
10	Lithium-Polymer Voltage
11	Lithium-Ion Voltage
12-13	Checksum

Table 2.5: Battery status packet fields.

Subsystems status packet

Figure 2.7, and table 2.6 summarize the structure of the packet and the information of each field.

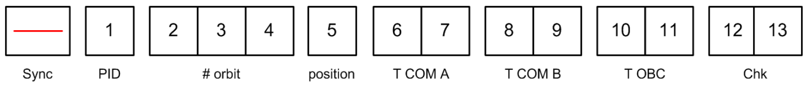


Figure 2.7: Beacon Subsystems status packet

Character	Name
1	Packet ID and processor ID
2-4	Orbit number
5	Approximate latitude
6-7	Alinco temperature
8-9	Beacon temperature
10-11	OBC temperature
12-13	Checksum

Table 2.6: Subsystems status packet fields

Photovoltaic temperature packet

Each of the 6 photovoltaic modules of *TIsat-1* is monitored by a thermometer. The temperature of the sides X-, Y+ and Z- are available in this packet.

The structure of the packet is shown in figure 2.8.
Refer to table 2.7 for decoding.

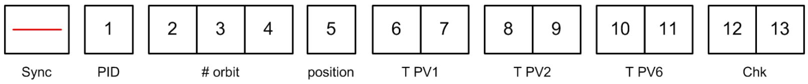


Figure 2.8: Beacon Photovoltaic temperatures packet.

Character	Name
1	Packet ID and processor ID
2-4	Orbit number
5	Approximate latitude
6-7	X- side temperature
8-9	Y+ side temperature
10-11	Z- side temperature
12-13	Checksum

Table 2.7: Photovoltaic temperature packet fields

Payload packet

On each side of *TIsat-1*, eight thin wire probes are exposed to the environment and are continously monitored to verify their degradation (break/no break) during time in space. The purpose of the test is to measure how long these wires survive in the Low Earth Orbit environment, in particular related to the effect of atomic oxygen. This is part of the experimental payload and is referred to as ”the material payload” in this document.

The status of four wires per side is available in the beacon payload packet, taking up 6 nibbles (fig. 2.9, M1 . . . M6). A bit value of ’0’ in these nibbles means ”wire interrupted”.
The issue of the test of an electromechanical device (microrelais) is available in character n. 12.

The structure of the packet is shown in figure 2.9.
Refer to table 2.8 for decoding.

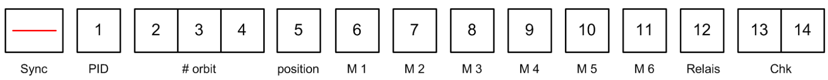


Figure 2.9: Beacon payload packet.

Character	Name
1	Packet ID and processor ID
2-4	Orbit number
5	Approximative latitude
6-11	Material payload
12	Relais payload
13-14	Checksum

Table 2.8: Payload packet fields

Complete packet

A longer packet, called *Complete packet*, merges the information of the four shorter beacon packet discussed in the previous sections. The data rate for the *Complete packet* is 100 WPM.
Field verification of communication reliability with packets of different length is one issue of interest for the *TIsat-1* mission.

The structure of the packet is shown in figure 2.10.
Refer to table 2.9 for decoding.

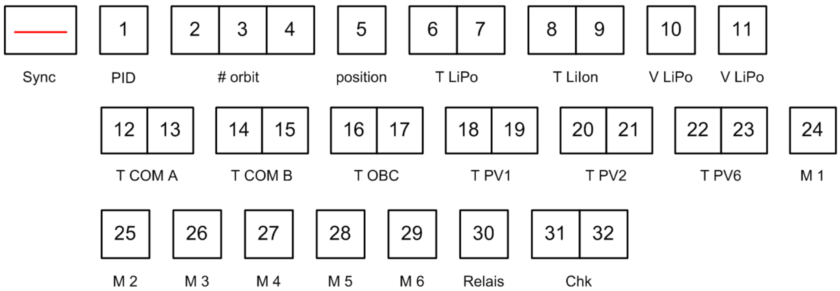


Figure 2.10: Beacon complete packet.

Character	Name
1	Packet ID and processor ID
2-4	Orbit number
5	Approximate latitude
6-7	Lithium-Polymer battery temperature
8-9	Lithium-Ion battery temperature
10	Lithium-Polymer battery voltage level
11	Lithium-Ion battery voltage level
12-13	Alinco temperature
14-15	Beacon temperature
16-17	OBC temperature
18-19	X- side temperature
20-21	Y+ side temperature
22-23	Z- side temperature
24-29	Material payload
30	Relais payload
31-32	Checksum

Table 2.9: Complete packet fields

2.3.6 Alinco Morse Packet Architecture

See section 2.3.5.

2.3.7 Alinco FSK Packet Architecture

The AM-FSK modulation is used to send a single packet of telemetry.
The data is represented in a single string of ASCII characters (letters, numbers, spaces and points) as in table 2.10.
The resulting string should appear as in figure 2.11. Negative values are appended in the string without space, beginning with their minus sign.

```
23.4 4.000 1.200 24.4 4.000 1.000 24.7 25.7 23.5 24.0 25.0 24.5 32.1-0.8 24.0-3.0 20.0-1.6
```

Figure 2.11: Example of Alinco FSK data string

Position	Description	Unit	Format
1	Lithium-ion battery temperature	^oC	± xx.x
2	Lithium-ion battery voltage	V	x.xxx
3	Lithium-ion current	A	± x.xxx
4	Lithium-polymer temperature	^oC	± xx.x
5	Lithium-polymer voltage	V	x.xxx
6	Lithium-polymer current	A	± x.xxx
7	FM radio board temperature	^oC	± xx.x
8	CW radio board temperature	^oC	± xx.x
9	EPS 1 board temperature	^oC	± xx.x
10	EPS 2 board temperature	^oC	± xx.x
11	OBC board temperature 1	^oC	± xx.x
12	OBC board temperature 2	^oC	± xx.x
13	PV generator side X- temperature	^oC	± xx.x
14	PV generator side Y+ temperature	^oC	± xx.x
15	PV generator side Z+ temperature	^oC	± xx.x
16	PV generator side X+ temperature	^oC	± xx.x
17	PV generator side Y- temperature	^oC	± xx.x
18	PV generator side Z- temperature	^oC	± xx.x

Table 2.10: Alinco FSK Packet Architecture

2.3.8 Alinco PSK Packet Architecture

For *TIsat-1* the PSK modulation offers the highest bit rate. PSK is therefore used to send the full telemetry and the *"orbit profiles"*, i.e. data collected and stored during the whole orbit.
Four PSK packets have been foreseen. Each of them contains one or more complete *profile* with a selection of different parameters.
The four PSK packets are transmitted sequentially and transmission is repeated over and over during the dedicated time-slice of *TIsat-1*.
Integrity of the data can be checked and some correction can be applied at the receiving end thank to a Golay(12,24) error detection and correction (EDAC) scheme implemented on *TIsat-1*.
Decoding of the PSK packets can be achieved even disregarding the EDAC scheme. In the next sections the PSK packets will therefore be presented first ignoring the EDAC check bits.
An explanation of how to deal with and take advantage of the EDAC bits will be given in section 2.3.8.

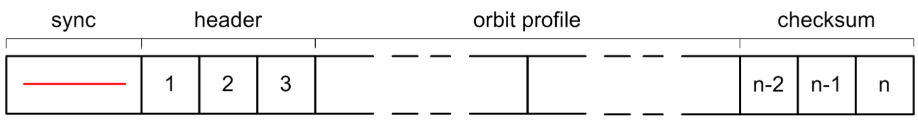


Figure 2.12: Structure of PSK packets
The *header* is followed by the *orbit profiles*, depending on packet ID.

Sync and Packet Header

Each PSK packet starts with a sequence of ones (11 bits), called Sync, followed by what we call the *header* (3 bytes), see figure 2.13. The PSK packet carries from 200 to 400 bytes (fig. 2.12).

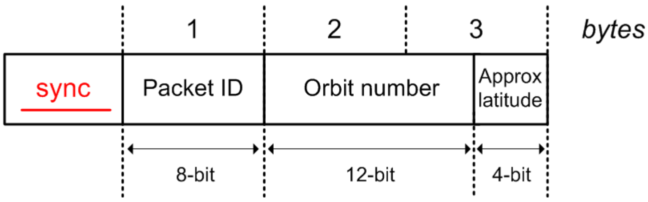


Figure 2.13: Sync + *Header* of PSK packets

Name	Size (bit)	Description
Sync	11	To synchronize detection of the packets. Eleven bit at '1'.
Packet ID	8	Identifier.
Orbit number	12	Total number of orbits completed at the time of transmission.
Approximate latitude	4	In $(\frac{1}{16} \cdot 360^o)$ starting from the terminator at orbit time.
	35	Total (bit)

Table 2.11: Sync + *header* fields of the PSK packets (refer to fig. 2.13)

Subsystems Packet: ID = 1

This packet carries information about the subsystems of *TIsat-1* recorded during the past 150 min (ca. 1.5 orbits) up to transmission time.
There are 30 data sets taken one every 5 minutes. Each data set holds temperature values

1. for the OBC (2 values),
2. for the EPS PCBs (2 values) and
3. for the COMM PCB (transceiver, 1 value)

Figure 2.14 shows the structure of this packet while table 2.12 explains its contents.

The collection of the 30 datasets with 5 parameters each is called *orbit profile* (OPR).

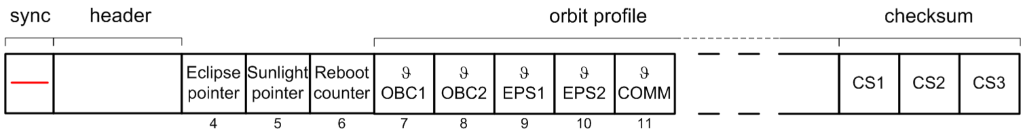


Figure 2.14: PSK subsystem packet, ID = 1

Name	Size (bit)	Description
Sync - Header	35	See table 2.11
Eclipse pointer	8	Identifies the first data set taken after orbital sunset.
Sunlight pointer	8	Identifies the first data set taken after orbital dawn.
Reboot counter	8	Number of unexpected reboots of the system from the beginning of the mission.
ϑ OBC1	8×30	Temperature of OBC (PCB sensor).
ϑ OBC2	8×30	Temperature of CPU1 (MSP internal sensor).
ϑ EPS1	8×30	Temperature of the EPS-TU subsystem.
ϑ EPS2	8×30	Temperature of the EPS-BM subsystem.
ϑ COMM	8×30	Temperature of the transceiver board.
CS1	8	Checksum 1
CS2	8	Checksum 2
CS3	8	Checksum 3
	1283	Total (bit)

Table 2.12: The PSK subsystems packet fields

Battery Packet: ID = 2

This packet is dedicated to the two batteries[7] of *TIsat-1*.

Each *orbit profile* holds 30 datasets taken one every 5 minutes during the most recent 150 min, up to transmission time. Each dataset holds temperatures and voltages as in figure 2.15.

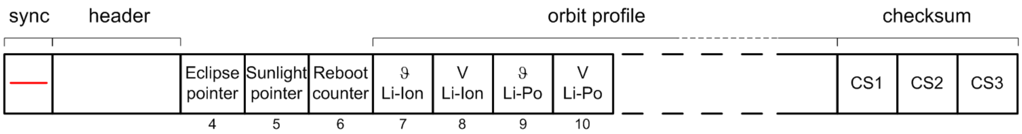


Figure 2.15: PSK battery packet

Name	Size (bit)	Description
Sync - Header	35	See table 2.11
Eclipse pointer	8	Identifies the first data set taken after orbital sunset.
Sunlight pointer	8	Identifies the first data set taken after orbital dawn.
Reboot counter	8	Number of unexpected reboots of the system from the beginning of the mission.
ϑ Li-Ion	8×30	Temperature of the Li-Ion battery.
V Li-Ion	8×30	Voltage of the Li-Ion battery.
ϑ Li-Po	8×30	Temperature of the Li-Po battery.
V Lithium-Po	8×30	Voltage of the Li-Po battery.
CS1	8	Checksum 1
CS2	8	Checksum 2
CS3	8	Checksum 3
	1043	Total (bit)

Table 2.13: The PSK battery packet fields

[7]Lithium-Ion battery (LiIon) and Lithium-Polymer (LiPo).

Photovoltaic Modules Packet: ID = 3

This packet carries temperature values of the backside of the 6 PV modules of *TIsat-1*. The values are recorded during the past 150 min (ca. 1.5 orbits) up to transmission time.
Every 10 minutes a new dataset with the 6 temperatures is taken. Accordingly 15 datasets are carried in this packet.

Figure 2.16 shows the structure of this packet while table 2.14 explains its contents. For the naming of the sides of *TIsat-1*, see fig. 2.1.

An *orbit profile* in this case is the collection of 15 datasets with 6 temperature values each.

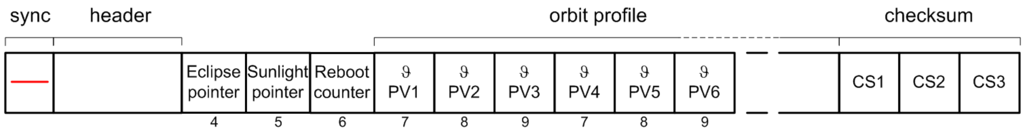


Figure 2.16: PSK PV modules packet.

Name	Size (bit)	Description
Sync - Header	35	See table 2.11
Eclipse pointer	8	Identifies the first data set taken after orbital sunset.
Sunlight pointer	8	Identifies the first data set taken after orbital dawn.
Reboot counter	8	Number of unexpected reboots of the system from the beginning of the mission.
ϑ PV1	8×15	Temperature, X- side
ϑ PV2	8×15	Temperature, Y+ side
ϑ PV3	8×15	Temperature, Z+ side
ϑ PV4	8×15	Temperature, X+ side
ϑ PV5	8×15	Temperature, Y- side
ϑ PV6	8×15	Temperature, Z- side
CS1	8	Checksum 1
CS2	8	Checksum 2
CS3	8	Checksum 3
	803	Total (bit)

Table 2.14: The PV modules packet fields

Payload and System Status Packet: ID = 4

This packet carries information about the actual system status (3 bytes) and payload status (18 bytes) as well as an *orbit profile* of the battery currents.

Each *orbit profile* holds 30 datasets with two battery current values. Each dataset is taken once every 5 minutes during the most recent 150 min (ca. 1.5 orbits) up to transmission time.

Figure 2.17 shows the structure of this packet while table 2.15 explains its contents.

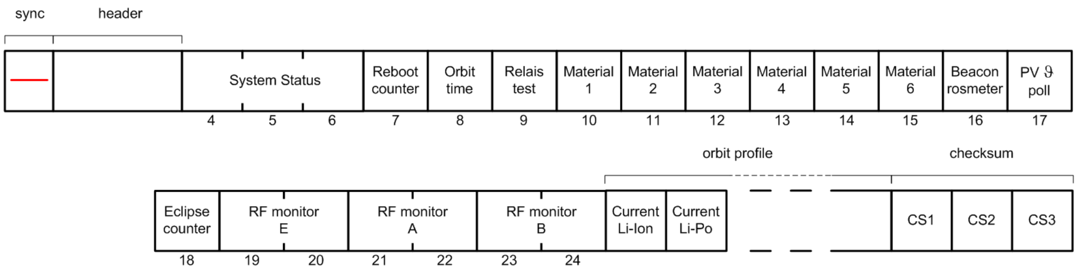


Figure 2.17: PSK payload and system status packet.

The ”RF monitor” parameter is picked up by a dedicated antenna circuit integrated on the PV modules, outside the metal structure of *TIsat-1*. It gives information about the spacecraft’s outer RF environment.

Name	Size (bit)	Description
Sync - Header	35	See table 2.11.
System status	24	Status of OBC and subsystems.
Reboot counter	8	Number of unexpected reboots from the beginning of the mission.
Orbit time	8	Orbit period (minutes)
Relais test	8	Test result for the micro-relais payload
Material 1	8	Material payload, X- side
Material 2	8	Material payload, Y+ side
Material 3	8	Material payload, Z+ side
Material 4	8	Material payload, X+ side
Material 5	8	Material payload, Y- side
Material 6	8	Material payload, Z- side
Beacon SWR-meter	8	Antenna match information for the beacon
PV ϑ poll	8	Bit-mapped information for temperature above or below 0^oC, for each side
Eclipse counter	8	Eclipse $\leftrightarrow$ sunlight transition sampling shiftregister.
RF monitor E	16	RF power
RF monitor A	16	RF power detected while the transceiver is operating.
RF monitor B	16	RF power detected while the beacon is operating.
Current Li-Ion	8	Current consumption from Lithium-Ion battery.
Current Li-Po	8	Current consumption from Lithium-Polymer battery.
CS1	8	Checksum 1
CS2	8	Checksum 2
CS3	8	Checksum 3
	243	Total (bit)

Table 2.15: The PSK payload and system status packet fields.

The Golay(12,24) EDAC scheme

All PSK packets are provided with redundant data to allow for error detection and correction (EDAC). The adopted Golay(12,24) EDAC scheme allows detection of up to 4 faulty bits[8] and correction of up to 3 bits on 12 bit dataframes. In presence of 5 and 6 errors, the algorithm is thrashed.

In the basic version of the algorithm, given 12 bits of data, 12 check-bits are calculated. Unfortunately, 12 (bits) is not a multiple of 8, so it is not possible to use entire bytes for the computation of Golay without a padding strategy. The firmware of *TIsat-1* takes clusters of three bytes and divides the resulting 24 bits in two words of 12 bits each. The first word takes the first byte and the most significant 4 bits of the second, whereas the second word takes the 4 least significant bits of the second bytes concatenated with the third byte.
Twelve check-bits are calculated for each of these 12 bit datawords, ending up with clusters of 3 data bytes and 3 check-bytes for a grand total of $24 + 24 = 48 bits$.

Figure 2.18 shows how these $48 bit$ clusters are concatenated to build the PSK information packet: three bytes of data followed by three bytes (two 12 bit groups) of check-bits.

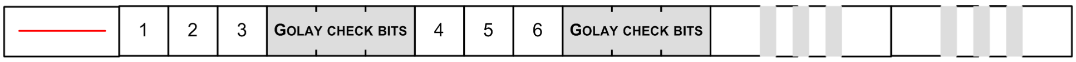


Figure 2.18: A PSK packet with the Golay(12,24) EDAC data (grey shaded).

[8]We say simply "4 errors".

2.3.9 Beacon Packet Coding Details

As one of the transmission modes of *TIsat-1*, Morse was chosen because it is easy to implement, easy to decode, is relatively resistant to noise and it is energy efficient.
Each Morse character in the beacon packets stays for a binary nibble of data (table 2.4).
The encoding system for each parameter is shown in this section.
The data fields in the beacon packets (fig. 2.6 through 2.10) are:

1. packet and processor ID (*PID*);
2. number of orbit (*#orbit*);
3. approximate latitude (*position*);
4. temperature;
5. voltage;
6. payload data.

Packet and Processor ID - *PID*

This field is included in every packet. It identifies both the packet type (2.3.5) and the processor issuing it (actually working on board).

PRO	ID2	ID1	ID0

bit3 bit0

bit 3 **PRO:** Processor Identification
0 = MSP430
1 = PIC18

bit 2-0 **ID2 . . . ID0:** packet type identification
001 = battery status
010 = subsystems status
011 = photovoltaic temperature
100 = payload
101 = complete

Example: PIC18 sending the Photovoltaic Temperature packet.

1	0	1	1

bit3 bit0

Number of orbit - *#orbit*

This field is included in every packet. It identifies the age of the mission in terms of the orbit number. The number is incremented by every eclipse to sunlight transition detected by *TIsat-1*.
Orbit counting is made with a 12-bit counter sent by 3 Morse characters for the 3 nibbles of the counter. The characters are chosen according to table 2.4.

MC2	MC1	MC0
MorseChar2		MorseChar0

MC2-MC0 Morse characters, encoding the nibbles of the 12 bit counter, according to table 2.4.

Example: Orbit number 723_{10}

MC2	**MC1**	**MC0**	
–	· · · · ·	– ·	dit-dah sequence
T	5	N	Alphanumeric characters
0010	1101	0011	Nibbles (table 2.4)
$001011010011_2 = 723_{10}$ $(\mathit{MC2} \cdot 16 + \mathit{MC1}) \cdot 16 + \mathit{MC0}$			Resulting orbit number

With the 12 bit counter and an orbit period of 97 minutes, *TIsat-1* can count orbits for roughly 9 months before the counter overflows:

$$\frac{97 \cdot 4096}{60 \cdot 24 \cdot 30} \approx 9 \ months$$

.

Approximate Latitude - *position*

This field is included in every packet. It identifies the approximate position of *TIsat-1* on its circular orbit, in units of $22.5^o = (0.393rad)$ counting from the crossing of the terminator.

When *TIsat-1* crosses the terminator, going from eclipse to sunlight, a 4 bit counter is reset. The counter is then incremented every $\frac{T_{orbit}}{16} \approx \frac{97\ minutes}{16} = 6.0\ minutes$.
In angular units per every counter unit this is

$$\theta \approx \frac{360^o}{16} = 22.5^o \approx 0.393rad$$

MC
MorseChar

MC Morse characters, encoding 4 bits for the approximate position of the satellite (table 2.4).

Example:

MC	
$- \cdot \cdot \cdot$	dit-dah sequence
B	Morse character
1100	Nibble (table 2.4).
$Position = (22.5^o \cdot MC)$ $(22.5^o \cdot 12_{10}) = 270^o$	Resulting position from the terminator.

Temperatures

All temperatures are encoded with two Morse characters chosen from the most convenient ones (shortest dit-dah sequences), thus saving energy.
Temperature decoding is a two step process.

MC1	MC0
MorseChar1	MorseChar0

MC1-MC0 Morse characters, encoding the 3 bits of the temperature value. Table 2.4 is used for values 0 to 7.

Example:

1. Derive intermediate value

MC1	**MC0**	
$- \cdot$	$- \cdot \cdot$	dit-dah sequence
N	D	Will be out of (E, I, T, N, S, A, H, D)
0011	0111	Nibbles (table 2.4). MSB is always zero.
00 011 111		**Intermediate Value** Concatenate the 3 least significant bits of both characters and pad with zero. Consider MCi as bit vector MCi(3 downto 0) and the sign & as concatenation sign. The intermediate value is "00" & MC1(2 downto 0) & MC0(2 downto 0).

2. Calculate real temperature

$$\begin{aligned} Temperature &= \frac{(IntermediateValue \cdot 64) - 150}{100}\ ^oC \\ &= \frac{(MC1 \cdot 8 + MC0) \cdot 64 - 150}{100}\ ^oC \end{aligned}$$

Where MCi is the nibble value of the original Morse characters.

For the example:

$$\begin{aligned} Temperature &= \frac{(31_{10} \cdot 64) - 150}{100}\ ^oC \\ &= \frac{(3_{10} \cdot 8 + 7_{10}) \cdot 64 - 150}{100}\ ^oC \\ &= 18.34\ ^oC \end{aligned}$$

Temperature values are in the range $[-2^oC, 38^oC]$.

Voltages

Batteries voltages are represented by a single short-format Morse character.

MC
MorseChar

MC Morse characters, encoding 4 bits for the voltage value (table 2.4).

Example:

MC	
$- \cdot \cdot \cdot$	dit-dah sequence
B	Morse character
1100	Nibble (table 2.4).
$Voltage = \frac{MC+27}{10}\ V$ $Voltage = \frac{12_{10}+27}{10} = 3.9\ V$	Resulting voltage

Voltage values are in the range $[2.7\ V, 4.2\ V]$.

Payload Data

Material Payload. Refer to page 17 for introductory information on Material Payload and to figure 2.9 for the packet structure.
The encoding of the Morse characters 6 to 11, each representing the status of four wires, is shown in table 2.16.

Packet Field #	Side	bit	Material
6	X-	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	Bonding Wire
7	Y+	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	Bonding Wire
8	Z+	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	*DynaCable*
9	X+	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	Bonding Wire
10	Y-	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	Bonding Wire
11	Z-	3	Bonding Wire
		2	Bonding Wire
		1	Bonding Wire
		0	Bonding Wire

Table 2.16: Materials payload details (refer to fig. 2.9)

Microrelais Payload. The team of *TIsat-1* wanted to verify if a small electromechanical device, a microrelais, would survive the high stress of the launch and the extreme environment conditions of LEO[9]. Thus *TIsat-1* carries a microrelais which will periodically be activated by the processors while monitoring the contact position. If the relay is working correctly, the 12^{th} Morse character of the payload packet (fig. 2.9) will be 'K' (see table 2.4 for the corresponding binary encoding). Any other character identifies a test-failure.

[9]LEO: Low Earth Orbit

Checksum

An eight bit checksum is appended to each data packet to allow some verification of data correctness. It is calculated as

$$CheckSumByte = 256 - \left[(\sum^{\forall i} byte_i) \bmod 256 \right] \tag{2.5}$$

where the index i indicates all data bytes contained in the packet.

The *bytes* for calculation are formed either concatenating two Morse characters (nibbles, according to table 2.4), or left padding a single nibble with four zeros.
At the receiving end, the sum can be recalculated using the received data. If the computed checksum matches the one received from the satellite, the data are most probably correct. Not all possible errors can be detected with this method.
Notice that, by definition, an error in the checksum does not automatically invalidate the packet received: it is only an information value.

To calculate the checksum two different procedures, depending on the packet type, are used.

Checksum for Beacon Payload and Complete Packets.

1. Concatenate (&) the received characters in couples except for characters 1 and 12 (fig. 2.19).

2. Decode each character in a 4-bits value according to table 2.4.

3. Left pad characters 1 and 12 with zeros.

4. Each couple or padded character is a byte (8-bits value). The right most couple is the checksum computed on the satellite and included in the packet.

5. Add all the bytes (including the checksum byte) modulo 256 to calculate

$$GroundCheck = \left[(\sum^{\forall i} byte_i + CheckSumByte) \bmod 256 \right] \tag{2.6}$$

6. Verification: if $GroundCheck = 0$ the checksum may be correct else it is wrong and the packet has to be considered corrupted[10].

Calculating *GroundCheck* for the data of figure 2.19 yields

$$(581 + 187) \bmod 256 = 768 \bmod 256 = 0$$

showing a correct checksum.

[10] Checking for $GroundCheck = 0$ is the same as recalculating the *CheckSumByte* (eq. 2.5) at the receiving end and looking if it is equal or not to the checksum received from the spacecraft.

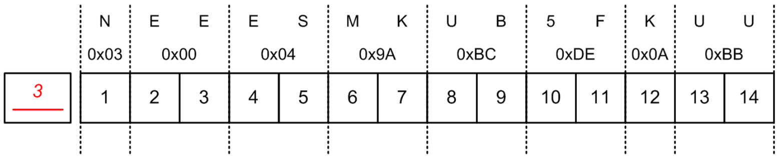


Figure 2.19: Payload packet: example checksum computation

$$(0\&N) + (E\&E) + (E\&S) + (M\&K) + (U\&B) + (5\&F) + (0\&K) \overset{tab.2.4}{\Longrightarrow}$$

$$\overset{tab.2.4}{\Longrightarrow} (\mathit{0x03} + \mathit{0x00} + \mathit{0x04} + \mathit{0x9A} + \mathit{0xBC} + \mathit{0xDE} + \mathit{0x0A}) = 581_{10}$$

$$(581 \bmod 256) = 69$$

$$CheckSumByte = (256 - 69) = 187 = \mathit{0xBB} \overset{tab.2.4}{\Longleftrightarrow} UU$$

Checksum for Beacon Packets except Complete and Payload

1. Concatenate (&) the received characters as shown in figure 2.20.
2. Decode each character in a 4-bits value according to table 2.4.
3. Left pad character 1 with zeros.
4. Each couple or padded character is a byte (8-bits value). The right most couple is the checksum computed on the satellite and included in the packet.
5. Add all the bytes (including the checksum byte) modulo 256 (equation 2.6).
6. Verification: if the result is 0 the checksum may be correct else it is wrong and the packet has to be considered corrupted.

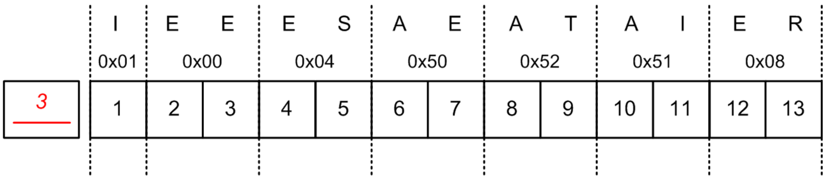


Figure 2.20: Beacon packets, except payload and complete: example for checksum computation.

$$(0\&I) + (E\&E) + (E\&S) + (A\&E) + (A\&T) + (A\&I) \overset{tab.2.4}{\Longrightarrow}$$

$$\overset{tab.2.4}{\Longrightarrow} (\mathit{0x01} + \mathit{0x00} + \mathit{0x04} + \mathit{0x50} + \mathit{0x52} + \mathit{0x51}) = 248_{10}$$

$$(248 \bmod 256) = 248$$

$$CheckSumByte = (256 - 248) = 8 = \mathit{0x08} \overset{tab.2.4}{\Longleftrightarrow} ER$$

2.3.10 Alinco Morse Coding Details

The Alinco Morse Coding is the very same as the coding for the Beacon. Please refer to section 2.3.9.

2.3.11 Alinco FSK Coding Details

The FSK modulation is plain ASCII, not encoded.

2.3.12 Alinco PSK Coding Details

PSK Packets: System Status Encoding

System Status is bit mapped into three bytes of the ”Payload and System Status Packet” (ID = 4, pag. 25). This data structure is mainly legacy from ground debug-time facilities and is of use for the *TIsat-1* mission team only.

This is an undocumented feature.

Bit	Name	Description
0	Debug state	if '1' debug mode is disabled
1	Alinco ON/OFF	if '1' Alinco is ON
2	Alinco error	if '1' Alinco not responding
3	Modem transmit	if '1' the firmware modem is configured to transmit.
4	Modem receive	if '1' the firmware modem is configured to receive.
5	Modem Morse mode	if '1' the transmitter firmware modem is configured for Morse
6	Modem melody mode	if '1' the transmitter firmware modem is configured in special tone-melody mode
7	–	reserved
8	–	reserved
9	Beacon ON/OFF	if '1' the beacon is ON
10	I^2C state	if '1' = ready, '0' = not configured
11-15	–	not used, should always be '0'
16	RTC error	RTC failure to send acknowledge on the I2C bus
17	Eclipse sensor error	Stored Eclipse value is unreadable (failure to get acknowledge bit on the memory-I2C bus or unrecoverable data error).
18	Dawn detection	Transition eclipse to sunlight detected
19	Sunset detection	Transition sunlight to eclipse detected
20	Orbit number error	Stored number of orbits is unreadable (failure to get acknowledge bit on the memory-I2C bus or unrecoverable data error).
21	I^2C bus error	I^2C bus bridge general error (PCA9554 not responding).
22-23	–	not used, should always be '0'

Table 2.17: Bit mapping of the system status for PSK packets.
The first two bytes (*system status*) are exposed in the upper part of the table while the last byte (*sensor status*) is on the lower

PSK Packets: Temperature Encoding

All temperatures are represented with one byte. The real temperature in ^{o}C can be calculated with

$$Temperature = \frac{byte \cdot 256 - 40}{10} \tag{2.7}$$

PSK Packets: Voltage Encoding

All voltages are represented with one byte. The real voltage in V can be calculated with

$$Voltage = \frac{byte \cdot 256 - 40}{1000} \tag{2.8}$$

PSK Packets: Current Encoding

All currents are represented with one byte. The real value of the current in A can be calculated with

$$Current = \frac{byte \cdot 256}{1000} \tag{2.9}$$

PSK Packets: Payload Encoding

The encoding of the material payload packet (fig. 2.17 and table 2.15) is shown in table 2.18. Each bit is associated with a material probe. Reading the value '1' means that the probe is broken.

Field #	Side	Bit	Material
6	X-	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed
		1	Bonding Wire, 30um, Au, exposed
		0	Bonding Wire, 30um, Au, exposed
7	Y+	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed
		1	Bonding Wire, 30um, Au, exposed
		0	Bonding Wire, 30um, Au, exposed
8	Z+	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed

Continued on next page

Continued from previous page

Field #	Side	Bit	Material
		1	Bonding Wire, 30um, Au, exposed
		0	*DynaCable*
9	X+	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed
		1	Bonding Wire, 30um, Au, exposed
		0	Bonding Wire, 30um, Au, exposed
10	Y-	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed
		1	Bonding Wire, 30um, Au, exposed
		0	Bonding Wire, 30um, Au, exposed
11	Z-	7	PCB 0.2mm, 35um Cu, soldermask protected
		6	PCB 0.8mm, 35um Cu, soldermask protected
		5	PCB 0.2mm, 35um Cu, Au-coated, exposed
		4	PCB 0.8mm, 35um Cu, Au-coated, exposed
		3	Bonding Wire, 30um, Au, exposed
		2	Bonding Wire, 30um, Au, exposed
		1	Bonding Wire, 30um, Au, exposed
		0	Bonding Wire, 30um, Au, exposed

Table 2.18: Materials payload details.

Byte n. 9 of the PSK payload packet (fig. 2.17) reports about the issue of the relay test. The device is switched on and off several times by each processor while observing correct contact travel. If the relay is confirmed to work correctly the byte will read 0xAA. Any other result is to be considered a failure of the relay.

Checksums

In addition to EDAC (pag. 27), three bytes of checksum are used in each PSK packet to allow checking its correctness. The three bytes are calculated as follows.

Assume there are n bytes in a PSK packet.

Checksum 1 is computed with all the bytes of the packet preceding the CS1 byte with following equation.

$$CheckSum_1 = 256 - \sum_{i=0}^{n-1} (byte_i \bmod 256) \qquad (2.10)$$

Checksum 2 is the xor function of all the bytes preceding the CS2 byte, including the CS1 byte.

$$CheckSum_2 = byte_0 \oplus byte_1 \oplus \ldots \oplus byte_k \oplus \ldots \oplus byte_{n-1} \oplus \mathit{CS1} \tag{2.11}$$

Checksum 3 is computed xor-ing each byte of the PSK packet with its position index in the packet and all the results to each other.

$$\begin{aligned} CheckSum_3 \;=\;& (byte_0 \oplus 0) \oplus (byte_1 \oplus 1) \oplus \ldots \oplus (byte_k \oplus k) \oplus \ldots \oplus \\ & (byte_{n-1} \oplus (n-1)) \oplus \\ & (\mathit{CS1} \oplus n) \oplus (\mathit{CS2} \oplus (n+1)) \end{aligned} \tag{2.12}$$

2.4 Uplink

The uplink channel is reserved for commands to control the behavior of *TIsat-1*. DTMF encoding is used.

The description of the recognised commands will be available in due course.

Chapter 3

TIsat Demodulator User's Manual

3.1 Basic Concepts

TIsat Demodulator is a piece of software intended to demodulate and decode data from *TIsat-1*. Audio signals from a radio receiver are first digitized through the sound card of a personal computer and than analyzed by the demodulation/decoding software according to the selected modulation and/or encoding format.
The received data is collected and stored in logfiles while being displayed in user-friendly window-frames. The logfiles can then be submitted to SUPSI-SpaceLab through a HTTPS connection system embedded inside the demodulation software.

The following sections explain the fundamental concepts of the software. Sections 3.2 and 3.3 are targeted on the utilization of the software and assume that users known the basic concepts.

3.1.1 Download

TIsat Demodulator can be downloaded only after registering to the SUPSI-SpaceLab forum. Registration is absolutely free and personal data are stored only in the forum. SUPSI-SpaceLab data treatment policy guarantees that data are not transmitted, nor accessed, nor utilized outside of the forum section.

3.1.2 Soft- and Hardware Requirements

TIsat Demodulator is currently available only for Windows systems, it has been tested with Windows XP (SP 2 or 3), Windows Vista and Windows 7.
It requires the Microsoft .NET Framework version 2.0 or higher.
The minimum hardware configuration is rather modest and requires:

1. Pentium III 1 GHz (or equivalent);

2. 512 MB RAM;

3. sound card with 16 bit 44100 samples;

4. internet connection.

3.1.3 Workspace

The *workspace* is a user location (a directory) where *TIsat Demodulator* works. The contents of this location is generated and modified directly by *TIsat Demodulator* and should not be changed in any other way. The structure of a *workspace* consists in a folder named `TIsatLog` containing the log files (see next section for details) and an XML configuration file.

Create a Workspace A *workspace* can be created either during installation (see section 3.2) or during normal operation mode, by selecting `New Workspace` from menu `File`. In both cases the creation dialogue is the same. One has to choose the location where the workspace will be created and insert the name of the workspace. Following the confirmation a folder named as the workspace is created at the chosen location and will contain the XML configuration file with the same name as the workspace and the folder for the log files.

Open a Workspace A *workspace* can be opened either during the installation (see section 3.2) or during the normal operation mode by selecting `Open Workspace` from menu `File`. In both cases the opening dialogue is the same. One has to browse to the location where the desired *workspace* is located, open the folder named as the *workspace* and select the XML configuration file of the *workspace*. By confirming the opening, the software will load the workspace starting from that configuration file.

3.1.4 Logs and Feedback

Logfiles are located into the `TIsatLog` folder inside the *workspace*. The logs are grouped by day, with a folder for each day named with `yyyymmdd`, e.g. for the 15 July 2010 the name will be `20100715`. The logfiles will be placed in these folders.
Logfiles are created for each reception and are named with a date-and-hour string predeced by the modulation type selected using the format

`MODULATION_yyyymmdd_hhmmss`

Example

The 4 July 2010 at 14:20:59 a PSK reception starts.
The logfile will be named `PSK_20100704_142059`.
If it was a Morse reception it would be named `MORSE_20100704_142059`.
In case of an AM-FSK reception `AMFSK_20100704_142059`.
Two logfiles are written for each reception:

1. the *packets* file and
2. the *raw* file.

The first contains only the data that have been recognized as packets (decoded) for a particular modulation, it is not ensured that packets are corrected. The second contains all data received and demodulated by the software.
The packet files are identified by a character `P`, while a character `R` appended to the name of the log files identifies raw data files.
For the previous example:

- the log file of the packets received for the Morse modulation would be `MORSE_20100704_142059_P.log` while
- `MORSE_20100704_142059_R.log` would be the name of the logfile with raw data.

Log files are readable with any text editor. They are formatted in three sections: *Header, Data, Termination.*

Header The header contains the information shown in table 3.1.

Parameter	Value	Description
Version	String	Version of the software that generated the file
type of log	RAW DATA LOG, PACKET LOG	type of log-file
username	string	
modulation	MORSE, PSK_NRZ, AMFSK	type of demodulation format selected
Start logging	date	time stamp of the creation of the file

Table 3.1: Log-files header

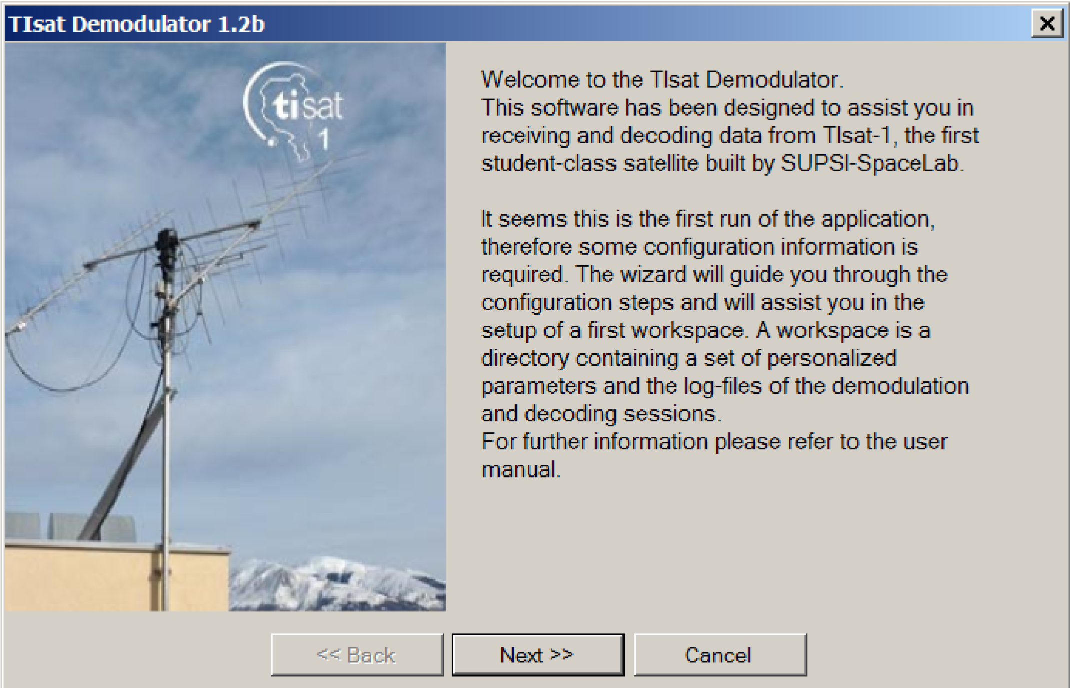
Data Raw data are written as in the raw data area (number 2 in figure 3.1). Packet data are collected with the time stamp of the reception and the content of the packet.

Termination Contains the termination time stamp of the logging session.

3.2 Installation

To install *TIsat Demodulator* users shall unzip the installation packet and run `setup.exe`. An installation wizard will guide them trough the procedure. Once the installation has been completed, the user can start *TIsat Demodulator* for the first time. This will invoke a configuration wizard with the following steps.

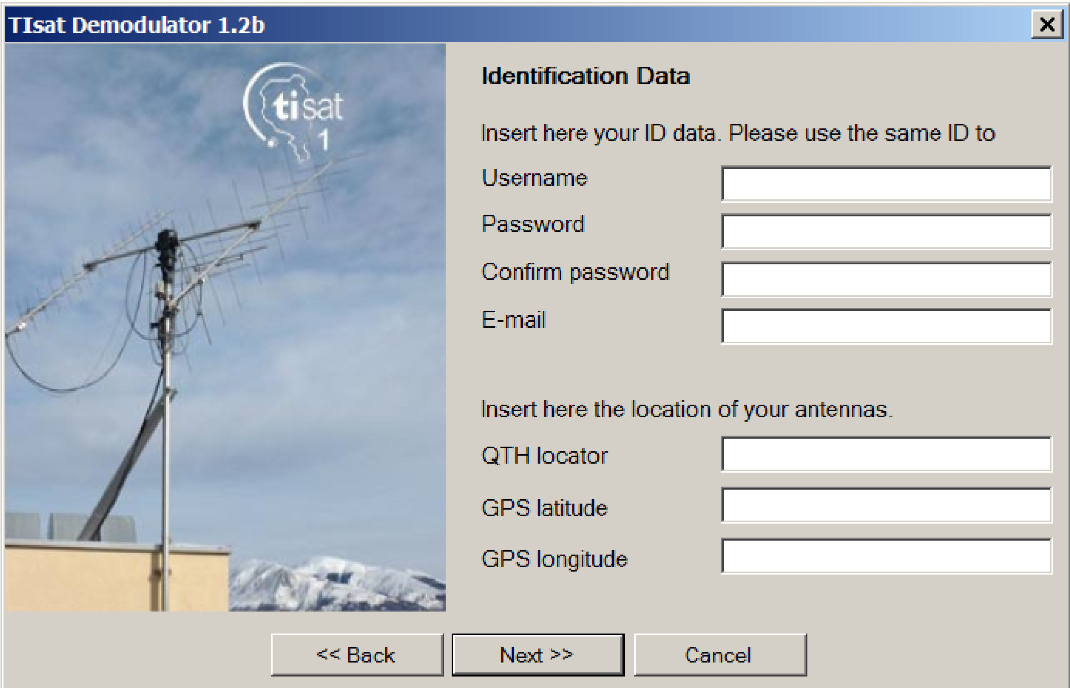
Configuration step 1 : welcome



Press next.

Configuration step 2 : identification data

Users are invited to insert into the text fields the data to identify themselves. Note that `username`, `password` and `e-mail` are mandatory, other fields are optional. To allow an automatic registration of the data received from *TIsat-1* `username` and `password` must be the same used to register to the forum of SUPSI-SpaceLab. Otherwise, the software will allow you to receive data, but will not upload them automatically.



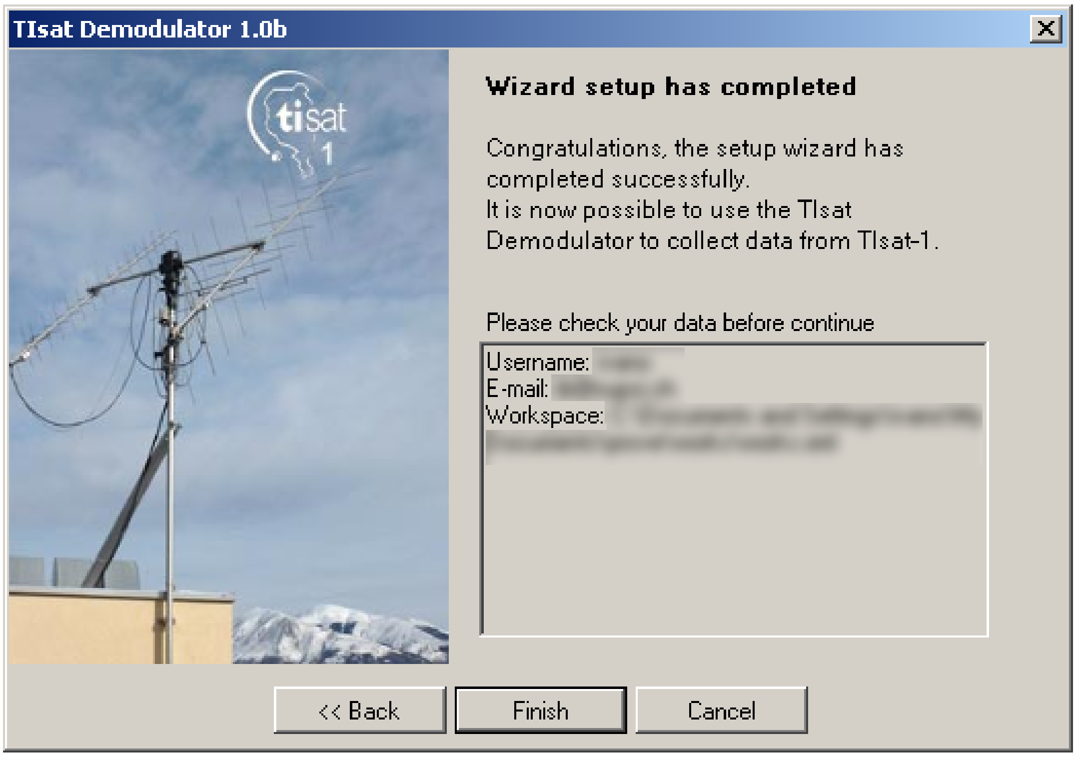
Configuration step 3 : first workspace

This step is used to configure the workspace to be used when *TIsat Demodulator* is started for the first time. Later it is always possible to create, open and use other workspaces. Users can choose:

- if a workspace already exists the `Open Workspace` button;
- if no workspace exists the `Create Workspace` button.

Configuration step 4 : confirmation

At the final step of the wizard, the previously inserted data are summarized. If something must be corrected, one can press the `Back` button as usual. Notice that when going backward through the wizard, the data are already set, so it is not necessary to retype them.



3.3 Usage

TIsat Demodulator has been designed to be very easy to use. A print-screen of the application is shown in figure 3.1. The red numbers represent the 4 steps to be executed to successfully receive, demodulate and decode data. These steps are:

1. In the control area, select the right audio peripheral, the desired demodulation format (see chapter 2) and press *Start sampling* to start the demodulation. Press *Stop* to stop the process.
2. The raw data area continuously displays the received data. The visualization can be single characters for Morse and AM-FSK and couple of hexadecimal numbers for PSK (binary telemetry).
3. The signal acquired by the sound card is continuously drawn in the graphic area. This demonstrated useful in the process of tuning the radio input level.
4. Each time a packet has been identified, it is inserted into the packet list. Double-click on a packet list entry shows a pop-up window with the decoded parameters of the packet.

Take care that the log file for the demodulation session is created when clicking on the *Start sampling* button and is closed when clicking on the *Stop* button.

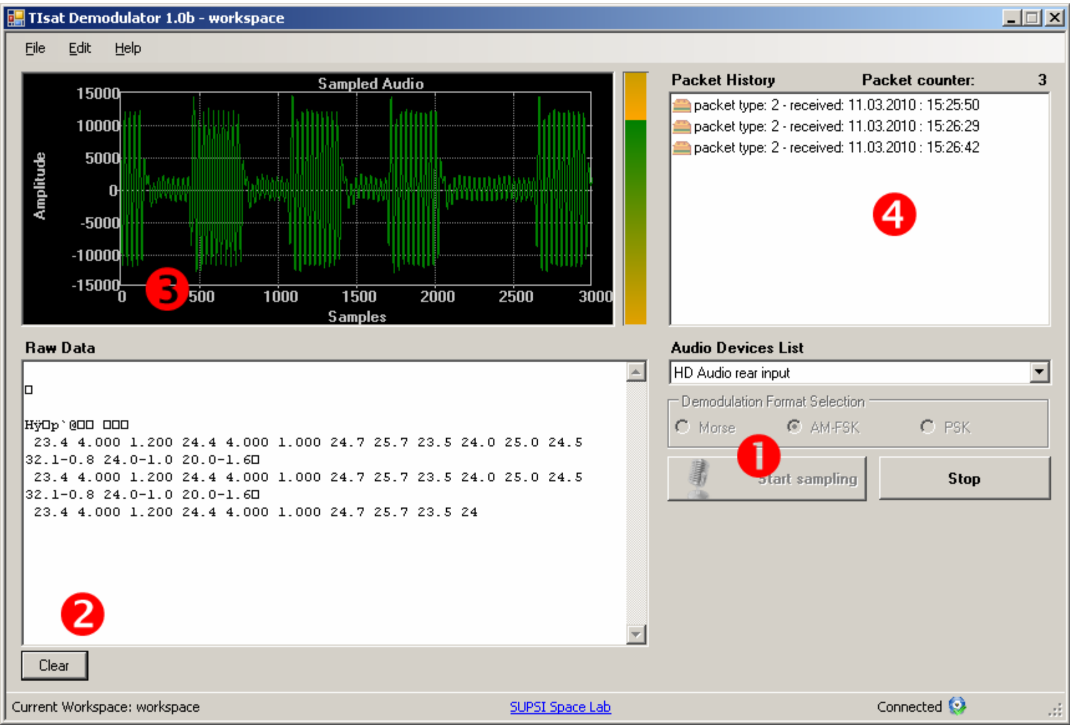


Figure 3.1: *TIsat Demodulator* operating.